CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-107

January 30, 1981

1. Name of fault

Hilton Creek fault, and unnamed northwest extensions of Hilton Creek fault in Long Valley caldera.

2. Location of fault

NW, NE, and SE quarters of Mt. Morrison 15-minute quadrangle, Mono County (figure 1).

3. Reason for evaluation

Surface fault rupture produced by earthquakes of May 25 and 27, 1980.

4. References

Bailey, R.A., 1974, Preliminary geologic map and cross-sections of the Casa Diable geothermal area, Long Valley caldera, Mono County, California: U.S. Geological Survey Open-file report.

Bailey, R.A., Dalrymple, G.B., and Lanphere, M.A., 1976, Volcanism, structure and geochronology of Long Valley caldera, Mono County, California: Journal of Geophysical Research, v. 81, no. 5, p. 725-744.

Bailey, R.A. and Koeppen, R.P., 1977, Preliminary geologic map of Long Valley caldera, Mono County, California: U.S. Geological Survey Open-file Report 77-468, map scale 1:62,500.

Bryant, W.A., Taylor, G.C., Hart, E.W., Kahle, J.E., Bedrossian, T.L., and McJunkin, R.D., 1980, Preliminary map of surface rupture associated with the Mammoth Lakes, California earthquakes, May 25 and 27, 1980: California Division of Mines and Geology Open-file Report 80-12SAC, 19 p., map scale 1:62,500.

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Hart, E.W., 1980a, Fault rupture hazard zones in California: California Division of Mines and Geology Special Publication 42, 25 p.

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Rinehart, C.D. and Ross, D.C., 1964, Geology and mineral deposits of the Mount Morrison quadrangle, Sierra Nevada, California: U.S. Geological Survey Professional Paper 385, 106 p. map scale 1:62,500.

Sherburne, R.W. (editor), 1980, Mammoth Lakes, California earthquakes of May 1980: California Division of Mines and Geology Special Report 150, 141 p.

Taylor, G.C. and Bryant, W.A., 1980, Surface rupture associated with the Mammoth Lakes earthquakes of 25 and 27 May, 1980: California Division of Mines and Geology Special Report 150, p. 49-67, map scale 1:62,500.

U.S. Forest Service, 1972, Aerial photos IN04-15 to 18, 20 to 28, 58 to 67, 70 to 79, 111 to 120, 123 to 131, 6-1 to 6, 10-1 to 8, 49 to 45, color, vertical, scale approximately 1:15,840.

U.S. Geological Survey, 1968, High altitude aerial photos USAF 374V 169 to 172, black and white, vertical, scale approximately 1:122,000.

5. <u>Review of available literature, air photo interpretation and field checking.</u>

Four M $\geq$ 6 earthquakes struck the Mammoth Lakes region in the southwestern portion of Mono County during May 25 and 27, 1980 (Sherburne, 1980) (figure 1). Surface rupture associated with this seismic activity occurred within a broad zone about 20 km long and up to 10 km wide along pre-existing late Quaternary faults (Taylor and Bryant, 1980) (figure 2a to 2c). Two distinct patterns of surface rupture were reported by Taylor and Bryant: (1) an essentially linear zone of north-northwest trending fractures along the Hilton Creek fault of Rinehart and Ross (1964) in the McGee Creek to Convict Creek area; and (2) a wide, complex, distributive zone of north and northwest trending fractures (Bailey and Koeppen, 1977) north-northwest of the intersection of Highway 395 and Convict Creek (figures 2a, 2b, 2c).

Observed offset due to probable fault displacement was generally extensional, although vertical displacement up to 30 cm occurred along the Hilton Creek fault in the McGee Creek area and along the west side of a prominent graben in section 28, T3S, R27E (figure 2a, 2c).

Rinehart and Ross (1964) mapped the Mt. Morrison IS-minute quadrangle, but fault traces shown are generalized and will not be evaluated in this Fault Evaluation Report (FER).

Bailey (1974) mapped the northern half of the Mt. Morrison quadrangle, showing in detail the distributive pattern of faulting within Long Valley caldera. Mapping by Bailey and Koeppen (1977) extends farther south to beyond the edge of the Mt. Morrison quadrangle. The map of Bailey and Koeppen (1977) generally is a compilation of Bailey's mapping in Long Valley caldera (1974) and mapping by others to the south, east, and west. Bailey and Koeppen's traces of the Hilton Creek fault in the McGee Creek area are depicted in greater detail than the traces of Rinehart and Ross (1964).

Faulting to be evaluated within the Mt. Morrison quadrangle has been divided into four groups in order to facilitate discussion in this FER. The four groups (or zones), based on a rather crude association of structural features, include: the Hilton Creek fault, East Fault Zone, Central Graben, and West Graben (figures 2a, 2b, 2c).

Hilton Creek Fault

The Hilton Creek fault, an east-dipping normal fault, was :first mapped by Rinehart and Ross (1964). About 1100 m of vertical offset, down to the east, ,is thought to have occurred during Quaternary time (Rinehart and Ross, 1964; Bailey and others, 1976). Rinehart and Ross (1964) show a Tioga-stage moraine (about 10,000 to 20,000 yr B.P.; Bailey and Koeppen, 1977) in McGee Creek to be offset vertically about 15 m (down to the east), indicating probable early Holocene offset (figure 2a). The contact between Cretaceous granitic rocks and Holocene colluvium is controlled by the Hilton Creek fault (Rinehard and Ross, 1964; Bailey and Koeppen, 1977). Bailey and Koeppen (1977) mapped the Hilton Creek fault in more detail, showing a slightly more complex style of faulting than Rinehart and Ross.

Surface rupture along the Hilton Creek fault associated with the May 1980 earthquakes was mapped in detail by Bryant and others (1980), Taylor and Bryant (1980), and Clark and others (1980). Vertical offset (down to the east) in colluvium averaged about 10 cm with about 10 cm of extension occurring in a zone about 1 m to 5 m wide. Maximum vertical offset of 27 cm along the Hilton Creek fault occurred in the northern portion of section 29 (figure 2a). It was not clear what amount of slumping had enhanced the fault rupture, but all fractures mapped were associated with east-facing scarps of the Hilton Creek fault and were consistent with the fault trend (Bryant and others, 1980; Taylor and Bryant, 1980; Clark and others, 1980).

Well-defined traces of the Hilton Creek fault, mapped by this writer based on field mapping during May 1980 and air photo interpretation, generally agree with the traces of Bailey and Koeppen (1977), but differences in detial and complexity of the fault exist. Evidence of Holocene offset along the Hilton Creek fault, in addition to surface rupture associated with the May 1980 earthquakes, includes: vertical offset of 15 m of Tioga-stage moraine deposits in McGee Creek; vertical offset of small drainages on the east slope of McGee Mt. (figure 2a).

<u>East Fault Zone</u>

The East Fault Zone may be the northern extension of the Hilton Creek fault into Long Valley caldera. The East Fault Zone is expressed as a discontinuous zone of distributive normal faulting along a geneal north to north-northwest trend (figure 2b, 2c). Bailey (1974) mapped traces of this fault zone in the Whitmore Hot Springs area north to section 30, and in a broad, generally north trending zone extending to sections 2 and 3, T3S, R28E. Bailey indicates that Holocene alluvium is offset near the junction of sections 5, 6, 7 and 8, T4S, R29E, (figure 2b).

Additional evidence of Holocene offset was observed in section 23, T3S, R28E where a drainage is offset vertically and in section 2, T3S, R28E where a closed depression is associated with a west-facing fault scarp (this report, figure 2b).

Well-defined but discontinuous fault scarps, based on air photo interpretation and field checking by this writer, characterize traces of the East Fault Zone from Highway 395 north to about section 30, T3S, R29E. Discontinuous surface rupture associated with the May 1980 earthquakes occurred along most of these fault traces and is detailed in Taylor and Bryant (1980) (figure 2b). Displacement was principally extensional, although vertical displacement to 5 cm (down to the east) was observed along a well-defined fault scarp near the NE 1/4 of section 36, T3S, R28E. Total vertical displacement of about 5 cm in a zone about 100 m wide occurred along north-trending faults just north of Whitmore Hot Springs (figure 2b).

Cental Graben

The Central Graben is a very prominent northwest-trending structure extending from section 7, T4S, R29E to section 6, T2S, R27E (figure 2a,b,c). Bailey (1974) mapped this structure in detail. Fault traces mapped by this writer, based on field mapping and air photo interpretation, generally agree with the traces of Bailey, although differences in detail exist. The Central Graben is bounded on the southwest by a complex zone of well-defined east and west-facing fault scarps that form a series of minor graben structures (figure 2b, 2c). The Central Graben is bounded on the northeast by a continuous series of southwest-facing fault scarps (figures 2a, 2b, 2c).

Holocene alluvium is vertically offset in the NW 1/4 of section 7, and a zone of discontinuous faults offset Holocene stream deposits of Hot Creek in section 34 (Bailey, 1974; Bailey and Koeppen, 1977)(figures 2a, 2b). A closed depression associated with a well-defined NW-trending fault scarp is located in the SE 1/4 of section 16, T3S, R28E, and in section 8, T3S, R28E, based on air photo interpretation and field checking by this writer (figure 2c).

Surface rupture associated with the May 1980 earthquakes occurred discontinuously along both the northeast and southwest boundaries of the Central Graben (Taylor and Bryant, 1980) (figure 2a, 2b, 2c). Maximum observed vertical offset of 30 cm occurred along the east-facing scarp of a prominent graben located in the SW 1/4 of section 28, T3S, R28E (figure 2c). Total vertical displacement along the Central Graben probably exceeded 30 cm because offset was distributed over several sub-parallel normal faults within the graben (Taylor and Bryant, 1980).

West Graben

The West Graben extends northwest from the NE 1/4 of section 4, T4S, R28E to Lookout Mt. and is characterized by generally well-defined fault scarps (figure 2c). Faults in the central part of the West Graben (sections 18 and 19, T3S, R28E) offset Holocene pumice deposits (Qp of Bailey, 1974) (figure 2c). Bailey and Koeppen (1977) map north and northwest trending faults that offset Holocene pumice deposits in sections 4, 9, 10 and 11, T3S, R27E (figure 2c). These faults are expressed as well-defined east and west facing scarps, based on air photo interpretation and field checking by this writer. A closed depression within a well-defined graben along the east flank of Lookout Mt. indicates Holocene offset along the northern extent of the West Graben (figure 2c).

Discontinuous surface rupture associated with the May 1980 earthquakes occurred along faults in the West Graben as far north as the NW 1/4 of section

18, T3S, R28E (Taylor and Bryant, 1980) (figure 2c).

6. Conclusions

Hilton Creek Fault

The Hilton Creek fault is an east-dipping normal fault. Well-defined east-facing scarps characterize this fault from section 33, T4S, R29E north to Highway 395. Evidence of Holocene faulting along the Hilton Creek fault is located at McGee Creek where a Tioga-stage moraine is vertically offset 15 m (east side down) (Rinehart and Ross, 1964; Bailey and others, 1976; Bailey and Koeppen, 1977). Additional evidence of Holocene offset includes vertical offset of small drainages that cross the Hilton Creek Fault (Bryant, figure 2a, this report) and offset Holocene colluvium along the east slope of McGee Mt. (Rinehart and Ross, 1964; Bailey and Koeppen, 1977).

Surface rupture associated with the May 1980 earthquakes occurred along traces of the Hilton Creek fault. Maximum vertical offset of about 27 cm occurred in the north part of section 29 (Taylor and Bryant, 1980) (figure 2a). Fault traces mapped by Bailey and Koeppen (1977) and Taylor and Bryant (1980) adequately delineate this fault.

East Fault Zone

The East Fault Zone is characterized by discontinuous, distributive faulting along a north to north-northwest trend. Well-defined but discontinuous fault scarps delineate most of the traces in this region. Holocene faulting is indicated by the offset of Holocene alluvium in sections 6 and 7, T4S, R29E (Bailey, 1974; Bailey and Koeppen, 1977), by the vertical offset of a drainage in section 23, T3S, R28E (figure 2b), and a closed depression associated with a west-facing fault scarp in section 2, T3S, R28E (figure 2b). Fault traces within the East Fault Zone are adequately delineated by Bailey (1974), Bailey and

Koeppen (1977), and Taylor and Bryant (1980).

Central Graben

The Central Graben is a prominent northwest-trending structure within Long Valley caldera. Well-defined east and west facing fault scarps characterize this region. Holocene fautling is indicated by vertical offset of Holocene alluvium in the NW 1/4 of section 7, T4S, R29E (Bailey and Koeppen, 1977), by vertical offset of Holocene deposits in section 34, T3S, R28E (Bailey and Koeppen, 1977), and by closed depressions associated with well-defined SW-facing fault scarps in sections 8 and 16, T3S, R29E (Taylor and Bryant, 1980; this report, figure 2c).

Surface rupture associated with the May 1980 earthquakes occurred discontinuously along the northeast and southwest boundaries of the Central Graben (Taylor and Bryant, 1980) (figures 2a, 2b, 2c). Maximum vertical offset of 30 cm (down to east) occurred along the west scarp of a prominent graben in the SW 1/4 of section 28, T3S, R28E.

Fault traces by Bailey and Koeppen (1977) and Taylor and Bryant (1980) adequately delineate faults in the Central Graben.

West Graben

Evidence of Holocene faulting within the West Graben includes well-defined scarps in Holocene pumice deposits (sections 18 and 19, T3S, R28E) (Bailey and Koeppen, 1977), north and northwest trending faults that offset Holocene pumice deposits in sections 4, 9, 10, and 11, T3S, R27E, and a closed depression bounded by a well-defined graben structure of the east flank of Lookout Mt. (figure 2c). Discontinuous surface rupture associated with the May 1980 earthquakes occurred along faults in the West Graben as far north as the NW 1/4 of section 18, T3S, R28E (Taylor and Bryant, 1980). Fault traces mapped by Bailey and Koeppen (1977) and

Taylor and Bryant (1980) adequately delineate faults within the West Graben.

7. Recommendations

Recommendations for zoning faults for special studies are based on the criteria of sufficiently active and well-defined (Hart, 1980a).

Hilton Creek Fault

Zone for special studies traces of the Hilton Creek fault, based on mapping by Bailey and Koeppen (1977), Rinehart and Ross (1964), and Taylor and Bryant (1980), shown on figure 3a.

East Fault Zone

Zone for special studies well-defined fault traces within the East Fault Zone shown on figures 3a, 3b, & 3c based on mapping by Bailey and Koeppen (1977) and Taylor and Bryant (1980).

Central Graben

Zone for special studies well-defined fault traces within the Central Graben shown on figures 3a, 3b, 3c, based on mapping by Bailey and Koeppen (1977) and Taylor and Bryant (1980).

West Graben

Zone for special studies well-defined fault traces within the West Graben shown on figure 3c, based on mapping by Bailey and Koeppen (1977) and Taylor and Bryant (1980).

8. Report prepared by William A. Bryant, January 30, 1981.

William A. Bryant

I generally concur with the recommendations. Delineate SSZ's as narrow as possible and omit minor (esp. pre-Holocene) faults.
EWH